Comments Primarily Related to the EMDF Waste Acceptance Criteria fact sheet
Due DOE June 7, 2022

Submitted to: OakRidgeEM@orem.doe.gov
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Subject: Comments primarily related to the Waste Acceptance Criteria fact sheet

On November 4, 2021, several former TDEC employees sent a letter concerning the Environmental Management Disposal Facility (EMDF) to EPA Administrator Michael S. Regan. The December 29, 2021, response from Acting Assistant Administrator Barry N. Breen stated the EPA, DOE, and TDEC will solicit and consider public comments on new information before EPA and DOE finalize the ROD. This response letter encouraged us to review new information added to the Administrative Record file as well as provided to the public on a dedicated website. The website includes the following new information:

EMDF Site Groundwater Characterization fact sheet

EMDF Waste Acceptance Criteria fact sheet

EMDF Water Quality Protection for Bear Creek fact sheet

Draft Record of Decision – July 2021

Draft ROD Responsiveness Summary

Technical Memo #1: Phase 1 Field Sampling Results (July 2, 2018)

Technical Memo #2: Phase 1 Monitoring (May 23, 2019)

Development of Fish Tissue and Surface Water Preliminary Remediation Goals (April 28, 2022)

Performance Assessment for the Environmental Management Disposal Facility at the Y-12 National Security Complex, Oak Ridge, Tennessee (April 23, 2020)

Composite Analysis for the Environmental Management Waste Management Facility and the Environmental Management Disposal Facility, Oak Ridge, Tennessee (April 16, 2022)

Link to the Oak Ridge Environmental Information System (OREIS)

1. Developing analytical Waste Acceptance Criteria (WAC) keeps being postponed. The Remedial Investigation and Feasibility Study Figure 6-31 has WAC and WAC Compliance Plan development after completion of the EMDF Performance Assessment and appropriately documented to be consistent with CERCLA prior to the Record of Decision. The Waste Acceptance Criteria fact sheet now has analytical WAC completed after the Record of Decision and included in the WAC Compliance Plan. It is clear from the analytical WAC in the D1 Record of Decision (which is what the public has to comment on) that WAC is inconsistent with CERCLA threshold criteria and onsite disposal at the proposed EMDF should not be the selected

remedial alternative. For onsite disposal to be selected, WAC consistent with CERCLA threshold criteria should be developed and documented. Further, said CERCLA consistent WAC should be presented to the public with another public comment period.

2. At the May 17, 2022, public meeting, a commenter identified the 6 best practices for appropriate public engagement and graded DOE on each best practice. One of the best practices is TRUST should be established. To this category the commentor gave DOE the grade of F. With that level of trust, I think DOE should hold another public comment period for waste acceptance criteria that includes analytical WAC, when it is complete, even if the NCP doesn't specifically require it.
3. The Waste Acceptance Criteria fact sheet states, "landfill inventory limits are based on a hypothetical scenario where the maximally exposed individual is drinking contaminated groundwater and eating fish impacted by a release from EMDF." The fact sheet then points to the EMDF Performance Assessment for justification to assign inventory limits only for Carbon-14, Tritium, Technetium-99, and Iodine-129 meaning an unlimited inventory of other radionuclides may be placed in EMDF. At EMWMF, radionuclides without WAC are not tracked, radionuclides without WAC limits are not included in determining whether EMWMF is overall protective, and inventories for those radionuclides are not included in the EMDF/EMWMF Composite Analysis. Inventories of all radionuclides disposed in EMDF should be tracked. When corrective action is needed in the future, people will need to know what was disposed where.
4. The Waste Acceptance Criteria fact sheet misrepresents waste to be disposed in EMDF. It says EMDF will accept much of the same types of wastes as the current onsite facility, implying that demolition waste and soils from Y-12 National Security Complex (Y-12) and Oak Ridge National Laboratory (ORNL) have similar levels of radionuclide and chemical contamination as demolition waste and soils from K-25 (ETTP). During DOE's presentation on the fact sheets at the May 17, 2022, public meeting, DOE's presenter said that they will be putting basically the same stuff in the proposed new landfill (i.e., EMDF) as the current facility (i.e., EMWMF). As was pointed out by at least one commentor, who retired from Oak Ridge National Laboratory (ORNL), the proposed site will receive waste from ORNL which is significantly different than most of the previous disposed waste.

   To clarify further, the Environmental Management Waste Management Facility (EMWMF) is not indicative of a future Environmental Management Disposal Facility (EMDF). K-25 (East Tennessee Technology Park or ETTP), Y-12, and X-10 (Oak Ridge National Lab or ORNL) have different radionuclide and Clean Water Act (CWA) pollutant waste profiles. K-25 (ETTP) has been the major focus for many years and is the source of most of the recent waste disposed in the EMWMF. Wastes from Y-12 and ORNL proposed to be disposed in a future EMDF are orders of magnitude more contaminated with CWA pollutants (e.g., Y-12 - mercury) and radionuclides than wastes from ETTP disposed in the EMWMF. Radionuclide activity concentrations in EMDF landfill wastewater are also projected to be orders of magnitude greater than radionuclide activity concentrations measured in EMWMF landfill wastewater. The EMDF Performance Assessment[i] and EMWMF/EMDF Composite Analysis[ii] show that waste disposed in EMWMF is not indicative of future waste proposed to be disposed at EMDF. DOE proposes to dispose a significantly greater inventory of radionuclides at EMDF than EMWMF.

Radionuclide Inventory Identified for Disposal in EMDF is Significantly Greater than Radiological Inventory Disposed at EMWMF			
	EMDF/EMWMF Composite Analysis Table B.1		EMDF Performance Assessment Table B.6[iii]
Isotope Name	Reported EMWMF Activity at FY 19 (Curies)	Composite Analysis Estimated Waste Inventory Activity at EMWMF Closure (Curies)	EMDF Estimated Waste Inventory Activity at closure for a subset of Radionuclides (Curies decayed to 2047)
Am-241	20.2	25.5	152
C-14^	2.77	3.5	7.43
Cm-244	-----	-----	326
Cs-137	-----	-----	3040
Eu-152	-----	-----	74
Eu-154	-----	-----	16.7
H-3^	12.1	15.3	28.8
I-129^	0.00115	0.00145	1.05
K-40	-----	-----	8.46
Ni-63	-----	-----	1740
Np-237	1.4	1.77	0.837
Pb-210	-----	-----	9.5
Pu-238	-----	-----	242
Pu-239/240	14	18	310
Pu-241	-----	-----	525
Pu-242	-----	-----	0.445
Ra-226	-----	-----	2.07
Sr-90	-----	-----	496
Tc-99^	170	215	7.23
Th-229	-----	-----	14.7
Th-230	-----	-----	4.94
Th-232	-----	-----	9.07
Th-234*	-----	-----	-----
U-232	-----	-----	26.3
U-233/234	433	547	1727
U-235/236	42	53	125.2
U-238	258	326	983

^Radionuclides that EMDF PA Table G.9 adjusts for activity loss due to leaching during the 25-year operational period.
*Th-234 should be in secular equilibrium with U-238.

Further, average leachate activity concentrations projected in the EMDF Performance Assessment at landfill closure are significantly greater than maximum leachate and contact water activity concentrations measured at EMWMF from October 2015 through June 2021.

Comparison of Maximum Measured Activity Concentration in EMWMF Leachate and Contact Water for the period of October 2015 to June 2021 with the Average Leachate Activity Concentration Projected in EMDF at Closure.			
	Maximum Activity Concentration Measured from October 2015 through June 2021 and Reported in OREIS Data		EMDF Projected Leachate Activity Concentrations at EMDF Landfill Closure
Isotope Name	EMWMF Leachate (pCi/L) Activity concentration >1 rounded to a whole number	EMWMF Contact Water (pCi/L) Activity concentration >1 rounded to a whole number	EMDF Performance Assessment Table C.5. at T=0 (pCi/L)
Am-241	0.708	0.245	29
C-14	20	22	2,450
Cm-244	Undetected at 0.473	Undetected at 0.201	6,230

Cs-137	5	Undetected at 5.89	787
Eu-152	14	16	1,420
Eu-154	9	6	321
H-3	10300	4,790	21,000
I-129	3	2	158
K-40	65	67	215
Ni-63	65	53	673
Np-237	Undetected at 0.207	0.685	16
Pb-210	2	0.987	73
Pu-238	Undetected at 0.457	Undetected at 0.458	4,640
Pu-239/240	Undetected at 0.235	Undetected at 0.364	5,950
Pu-241	Undetected at 47.5	Undetected at 18.6	10,100
Pu-242	Undetected at 0.476	Undetected at 0.286	9
Ra-226	1	1	0.5
Sr-90 / radioactive strontium	44 (Sr-90)	8 (radioactive strontium - total)	12,600 (Sr-90)
Tc-99	2120	28,500	2,690
Th-229	Undetected at 0.503	Undetected at 0.241	4
Th-230	2	0.586	1
Th-232	0.201	0.361	2
Th-234*	28	41	
U-232	0.455	Undetected at 0.263	404
U-233/234	2200	676	26,650
U-235/236	226	48	1,926
U-238	100	41	15,100

*Th-234 should be in secular equilibrium with U-238.

5. TDEC contracted with Neptune and Company, Inc. to review the EMDF Performance Assessment. Neptune and Company, Inc produced a report titled *A Review of the Performance Assessment and Composite Analysis for the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee Dated 12 October 2020.* This report documents and includes issues with the Performance Assessment that lead to questioning the validity of the Performance Assessment for determining Waste Acceptance Criteria. Many of these issues are unresolved. Categories of issues fit into the broad categories discussed in the report executive summary:
   - ***The EMDF PA "base case" radionuclide transport and dose assessment modeling is bounded by assumptions rather than structured to evaluate mechanistic modeling of all applicable events and processes.*** *This leads to inaccurate and incomplete modeling based on these constraining assumptions. Natural processes that will compromise the ability of the EMDF to isolate contaminants from the environment are either not incorporated into the base case modeling (e.g. gully erosion, "bathtubbing") or they are artificially constrained without supporting rationale (e.g. a twofold linear increase in infiltration up to year 1000, and no further cover degradation after that time). For example, a plausible mechanism leading to release of contaminants is a localized breach of containment at the top of the liner due to accumulation of water in the facility. A release resulting from this mode of failure, often referred to as bathtubbing, seems probable sometime during the compliance period specified by DOE, and such a scenario is considered in some detail in the PA's supporting documentation. Although modeling of this 'bathtub scenario' predicts unacceptable levels of radionuclides in groundwater at a point of assessment 100 meters from the edge of the*

landfill, this analysis is kept outside of the PA and the results are not used to evaluate facility performance.

- ***Contaminant fate and transport modeling does not adequately represent the natural system.*** *The PA does not address plausible fate and transport pathways including groundwater fracture flow, sheet and gully erosion of the cover, uptake of subsurface radionuclides by deep-rooted plants, and deposition of radon progeny in the cover from the upward diffusion of radon. One example is underprediction of times of travel for contaminants in groundwater. Studies conducted over decades in Oak Ridge have shown that many radionuclides migrate readily through the fractured rocks in Bear Creek Valley. The errors made in solute transport modeling result in the PA's conclusion that a member of the public consuming water or fish in the vicinity of the facility throughout the next millennium would receive a radiation dose from just one isotope, Carbon-14. The transport models should be calibrated using available results from the many field scale tracer tests that have been conducted in Oak Ridge and supplemented with models that incorporate the physics of solute transport in fractured media. Model predictions should be checked against Oak Ridge environmental monitoring data that yield independent estimates of travel times for many radionuclides.*
- ***The hydrogeologic contaminant transport processes that are modeled are not coupled with other contaminant transport processes.*** *This problem stems from using software that is not capable of coupling such systems. For example, the upward migration of radon and its progeny (and indeed its parents) is not coupled with the downward transport to groundwater. In nature, these processes occur simultaneously, so decoupling them can cause obscure potentially important interactions.*
- ***The lack of a fully probabilistic analysis misrepresents what may be important drivers in the analysis.*** *The "base case" for this assessment is a single deterministic calculation, affording no insight about the context of uncertainty. While a handful of select parameters are used in one-at-a-time sensitivity analysis calculations, these are selected based on their expected significance. Only a fully probabilistic analysis, where all model inputs reflect the uncertainty in their values, would reveal those parameters that have unexpected significance.*

6. The Waste Acceptance Criteria fact sheet points to the inadvertent intrusion pathway of exposure in the D1 ROD. The D1 ROD included inadvertent intrusion based on a 100 mrem/year EDE (effective dose equivalent) where the upper end of the CERCLA risk range equates to about 10 mrem/year EDE and relevant and appropriate requirement 10 CFR § 61.41 requires releases must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public. WAC proposed in the D1 ROD was not demonstrated to be protective of human health and the environment and are not consistent with relevant and appropriate requirements and therefore fail threshold criteria for onsite disposal to be selected as a remedial action under CERCLA. Further, Neptune and Company states in Performance Assessment Critical Issue 6 that *"there is no logical basis for excluding evaluation of groundwater pathways in a Chronic Post-Drilling residential scenario that includes exposure to cuttings from a groundwater supply well. Both of these exposure pathways should be included in this exposure scenario"*. In other words, exposure to people from drill cuttings from a borehole spread over a garden is evaluated but the cancer risk and non-cancer uranium toxicity from drinking and otherwise using water from that residential

water supply well after the well is completed is ignored. This should be incorporated into the inadvertent intrusion pathway of exposure and Waste Acceptance Criteria.

7. The EMDF is proposed to be constructed on a knoll and it is likely the EMDF landfill will have steep slopes. TN H_2O[iv] includes *"Tennessee's climate is changing .... Average annual rainfall is increasing, and a rising percentage of that rain is falling on the four wettest days of the year .... The data clearly indicate an increasing trend in precipitation across Tennessee. This trend is expressed by more frequent heavy rainfall, and greater annual precipitation amounts, contrasted with dry spells that are more likely to be more severe because very hot days will be more frequent - even though annual precipitation is increasing ... Consequently, the instance of flash flooding is more likely, in both urban and rural areas alike.... Finally, with abundant rainfall, which has increased over time, dry spells are more severe due to warmer night time low temperatures not reaching the dew point temperatures."* With climate change likely resulting in increased heavy rainfall and flash flooding with long dry spells likely damaging the vegetative cover, there should be an increasing likelihood of erosion or slope failure exposing waste over time. Human exposure to this waste should be evaluated and the WAC restricted to not cause a cancer risk in excess of the CERCLA 10-4 to 10-6 risk range.
8. Neptune and Company's comments include the following. Among other things, this discusses mobile forms of uranium. Waste Acceptance Criteria including inventory limits are needed for uranium, and its various isotopes and progeny, and uranium metal. It is unclear what other radionuclides were screened out in the Performance Assessment due to relatively large assumed kd values and assumed negligible cover degradation. This should be reevaluated, and other radionuclides added to the analyticalWaste Acceptance Criteria to protect groundwater and fish consumption.

2.2.4 Radionuclide Mobility

- *The PA and CA evaluate risks from only a small handful of constituents proposed for disposal: H-3, C-14, Tc-99, and I-129. Many other potential contributors to radiological dose and risk have been practically omitted from the analysis due to a combination of relatively large assumed Kd values and an assumption of negligible degradation of the performance of the engineered cover over both 1000- and 10,000-year periods of assessment. The most significant omission from the analysis is evaluation of relatively mobile forms of uranium, and its various isotopes and progeny.*
- *In dismissing other radionuclides from the analysis, their progeny are dismissed as well. Some of these progeny might have a low retardation factor and high dose effects, and should be considered. For example, the decay chain of U-238, even when limited to progeny with half-lives over 5 years, includes U-234, Th-230, Ra-226, Rn-222, and Pb-210. Radon-222 is a noble gas (with zero retardation) and although omitted from dose analyses in air, it can contribute strongly to doses by other exposure pathways and deposits another strong dose contributor, Pb-210 (and its progeny), in locations near the ground surface. Once U-238 progeny achieve secular equilibrium, doses from what was once purified U-238 can increase by orders of magnitude. The issue of the exclusion of doses from progeny (and specifically external doses from radon progeny) is not addressed in the R2 PA.*
- *The PA models a variety of materials using the same Kd values, which is not in keeping with common practice. Even the older Baes et al. (1984) and Sheppard and Thibault (1990) references provide different values for different materials. Approximately 50% of the waste is expected to*

consist of debris with *characteristics very different from those of local soil. Critically, this statement (R2 PA Executive Summary, p. ES-10) may not be correct: "Under a long-term performance scenario, contaminant retardation in the vadose zone beneath EMDF and within the saturated matrix of the fractured rock at the CBCV (Central Bear Creek Valley) site serve disposal system safety functions by delaying and attenuating impacts of radionuclide release at potential groundwater and surface water exposure points." Retardation is reduced in the fracture-dominated flow of the saturated zone. By applying the same Kd values in the fractured rock zone as at other locations in the model domain, longterm performance is overestimated. Accordingly, this approach understates long-term contaminant transport and dose consequences.*

- *Neptune's supplemental RESRAD modeling indicates that near-term (<1000 years) and long-term performance is substantially poorer than that shown in the PA when substituting recommended Kd values (geometric mean) for clay soil type (most analogous to shale) from the RESRAD DCH, Table 2.13.3 (Yu et al. 2015) for the base case values used in the PA. Base case Kd values are lower (more "conservative" inasmuch as contaminants move more quickly via water pathways) than the RESRAD DCH Kd values for elements with relatively large Kd values. However, the opposite is true for uranium and the more-soluble elements hydrogen, carbon, and technetium, and it is these more-soluble elements that are responsible for water-pathways doses. The influence on modeled future doses from using these lower Kd values is particularly evident if infiltration rates exceed the 1 in/yr "degraded condition" value assumed in the PA.*

9. The above comment on kd values and the comment on kd values in comments on the Water Quality Protection for Bear Creek fact sheet shows the effect of assumed kds in the EMDF Performance Assessment. WAC to protect groundwater use and ingestion of fish pathways should be calculated using kd values from ORNL Risk Assessment Information System, ANL RESRAD, and other authoritative sources.
10. TDEC contracted with Neptune and Company, Inc. to evaluate the EMDF Performance Assessment (PA). Neptune's review[v] states *uncertainty in the inventory of disposed radionuclides is likely to be one of the more significant sources of uncertainty in the PA results.* This means there is significant uncertainty in how much of what radionuclides will be disposed in the proposed EMDF.
11. The EMDF Performance Assessment calculates a mean residence time exposure of fish to C-14 based apparently on an assumption that the mean flow in Bear Creek replaces radionuclide contaminated water in Bear Creek with upstream creek water about every 53 minutes. TN H_2O[vi] includes *"Tennessee's climate is changing .... However, rising temperatures increase evaporation, which dries the soil and decreases the amount of rain that runs off into rivers. Although rainfall during spring is likely to increase during the next 40 to 50 years, the total amount of water running off into rivers or recharging groundwater each year is likely to decline 2.5 to five percent, as increased evaporation off sets the increased rainfall. Droughts are likely to be more severe because very hot days will be more frequent, so the impact of days without rain will be more pronounced."* Activities in Bear Creek surface water that fish are swimming in should be calculated based on low flow conditions, not mean flow.
12. The EMDF Performance Assessment assumes significant leaching of C-14, H-3, I-129, and Tc-99 to Bear Creek surface water during the operational life of EMDF. This is addressed in PA Critical issue 5: Waste Leaching.

Isotope	As-Generated Waste Activity	As-Disposed Waste Activity	Post Operational Waste Activity	PA Assumed Leaching to Bear Creek during landfill operations
C-14	5.43	2.88	0.54	81%
H-3	21	11.2	4.64	59%
I-129	0.766	0.407	0.35	14%
Tc-99	5.28	2.8	1.56	44%

13. **What are the results of DOE's modeling of differential settling of the landfill and how does this impact infiltration and the analytical WAC?** During DOE's presentation at the May 17th public meeting, DOE's presenter said for analytical waste acceptance criteria (WAC) development, DOE was modeling when and how the landfill may fail to inform what they can put in the proposed landfill. It was my previous understanding that DOE did not model differential settling because that would mean landfill failure and that DOE didn't model landfill failure. Modeling how the landfill may fail to inform Waste Acceptance Criteria and what may be placed in the landfill should include evaluating the impact of differential settling which should mostly occur within the first 100 years or so after closure.
14. The Administrative WAC on page 2 of the Waste Acceptance Criteria (WAC) fact sheet includes administrative WAC for PCBs. Disposal of PCB should be removed from the administrative WAC. The TSCA waiver for 40 CFR 761.75(b)(3), that *"There shall be no hydraulic connection between the site and standing or flowing surface water"* in the Site Groundwater Characterization fact sheet is not protective of human health and should not be granted. The existing EMWMF is authorized to accept TSCA PCB waste and control of discharge of PCBs to surface water has not been a priority for almost 20 years. The Focus Feasibility for Water Management[vii] even screened PCBs out from being a contaminant of concern for the proposed EMDF based on the number of detections of PCBs when detection and reporting limits were 100 to 1000 times higher than promulgated recreational use water quality criteria. Isolation of the EMDF site from surface water is needed during landfill operations, closure, and post closure to protect human health and the environment from PCB pollution.
15. Comparing the figure on page 2 of the Site Groundwater Characterization fact sheet with the following picture from the EMDF Performance Assessment, it is clear the current design has NT-D-10W stream bed under the berm along the northeastern edge of the waste disposal area for most of the length of EMDF. The drawing also shows upstream NT D-10W rerouted to NT-10 and NT 10 dammed and turned into a sediment pond. It is not specified whether current NT-D-10W will be turned into a temporary or permanent underdrain and, if so, how a porous channel to collect leachate and groundwater and route it to Bear Creek may impact WAC.

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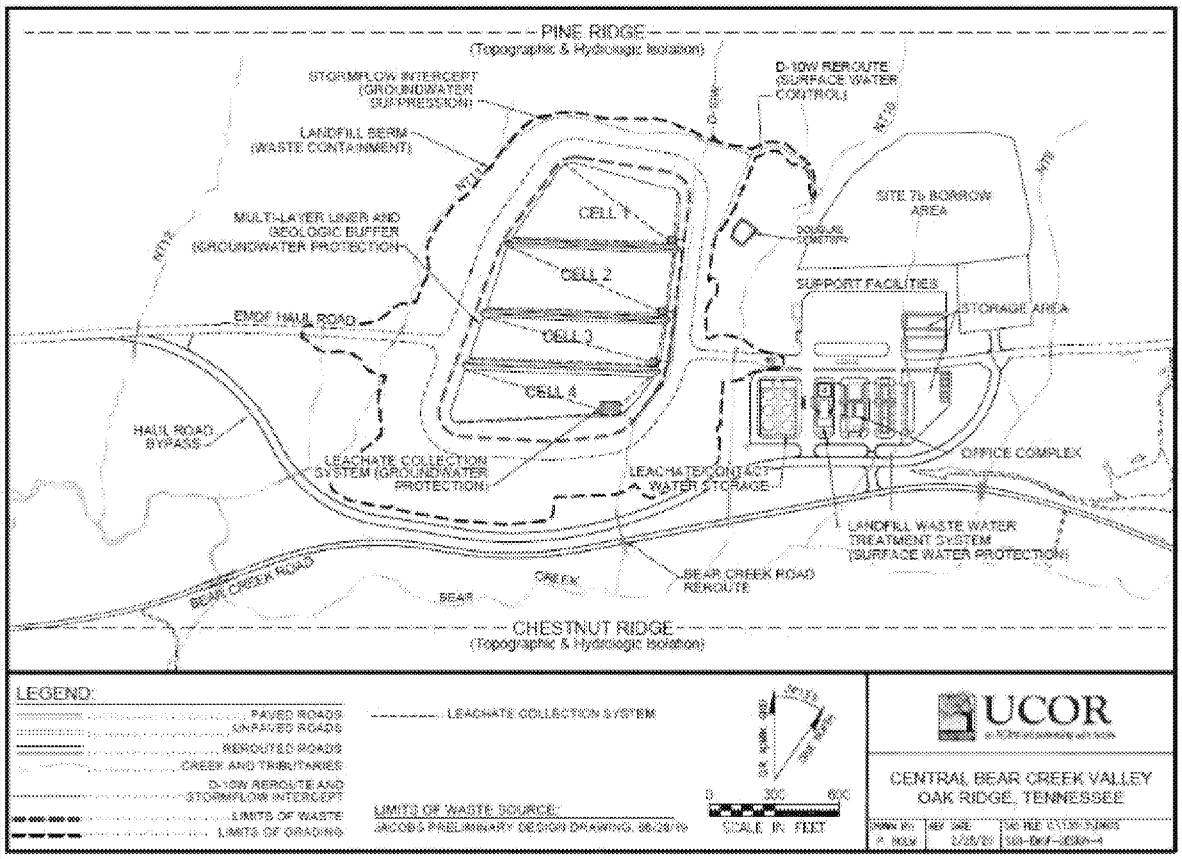

Fig. ES.4. EMDF site and design features and safety functions

These comments are respectfully submitted by:

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[i] Performance Assessment for the Environmental Management Disposal Facility at the Y-12 National Security Complex, Oak Ridge, Tennessee (UCOR-5094/R2)

[ii] Composite Analysis for the Environmental Management Waste Management Facility and the Environmental Management Disposal Facility, Oak Ridge, Tennessee (UCOR-5095/R2)

[iii]

Table B.6. Total EMDF radionuclide inventory (Ci decayed to 2047) (cont.)

Waste mass (g)	ORNL D&D	ORNL RA	Y-12 D&D Alpha-4 and Alpha-5	Y-12 D&D Biology	Y-12 D&D Remaining Facilities	Y-12 RA	EMDF Waste Total Inventory (Ci)	EMDF waste average activity concentration (pCi/g)
	1.94E+11	1.81E+11	1.37E+11	2.81E+10	3.03E+11	5.26E+11	1.37E+12	
Radio-isotope	EMDF activity by waste stream (Ci)							
Na-22	2.09E-06	2.63E-08					2.12E-06	1.55E-06
Nb-93m	Refer to Attachment B.3 for basis of inventory estimate						6.01E-01	4.39E-01
Nb-94	4.20E-02						4.20E-02	3.07E-02
Ni-59	7.84E+00						7.84E+00	5.73E+00
Ni-63	1.17E+02	1.62E+03		4.84E-02			1.74E+03	1.27E+03
Np-237	8.92E-02	5.08E-01	6.72E-03	6.04E-03		2.27E-01	8.37E-01	6.12E-01
Pa-231	6.15E-01						6.15E-01	4.49E-01
Pb-210	9.09E+00	4.08E-01					9.50E+00	6.93E+00
Pm-146	2.28E-04						2.28E-04	1.66E-04
Pm-147	5.49E-04	1.69E-05					5.66E-04	4.13E-04
Pu-238	1.43E+02	9.86E+01	2.52E-02		1.20E-01	4.62E-03	2.42E+02	1.77E+02
Pu-239	4.61E+01	1.04E+02			2.31E-02	3.12E-01	1.50E+02	1.10E+02
Pu-240	6.81E+01	9.18E+01	9.29E-03	5.07E-03			1.60E+02	1.17E+02
Pu-241	1.33E+01	5.12E+02					5.25E+02	3.83E+02
Pu-242	3.55E-02	4.10E-01					4.45E-01	3.25E-01
Pu-244	9.49E-03						9.49E-03	6.93E-03
Ra-226	5.68E-01	7.08E-01		2.80E-02		7.63E-01	2.07E+00	1.51E+00
Ra-228	1.27E-03	2.52E-03			5.17E-02	1.41E-03	5.69E-02	4.15E-02
Re-187	4.40E-06						4.40E-06	3.21E-06
Sb-125	7.82E-08						7.82E-08	5.71E-08
Sr-90	4.21E+02	7.50E+01		4.93E-02	5.02E-02		4.96E+02	3.62E+02
Tc-99	2.57E+00	7.11E-01	1.48E-01	1.14E+00	2.36E-01	2.43E+00	7.23E+00	5.28E+00
Th-228	2.25E-07	3.40E-10	8.14E-08	3.58E-07	4.78E-06		5.45E-06	3.98E-06
Th-229	3.36E-01	1.44E+01			1.43E-02		1.47E+01	1.08E+01
Th-230	3.30E-01	3.81E+00	5.92E-02		2.38E-02	7.20E-01	4.94E+00	3.61E+00
Th-232	2.32E-01	1.69E+00	5.14E-02	2.24E-02	1.98E-01	6.87E+00	9.07E+00	6.62E+00
U-232	1.62E-01	2.61E+01					2.63E+01	1.92E+01
U-233	5.15E+01	5.27E+01		2.71E+00	3.33E-01		1.07E+02	7.83E+01
U-234	2.15E+00	2.72E+01	1.25E+00	2.34E+00	1.58E+03	8.24E+00	1.62E+03	1.19E+03
U-235	8.15E-02	4.23E-01	1.02E-01	2.02E-01	9.57E+01	5.84E+00	1.02E+02	7.47E+01
U-236	5.14E-02	1.95E-01	5.22E-02	1.19E-01	2.26E+01	1.19E-01	2.32E+01	1.69E+01
U-238	1.32E+00	5.27E+00	4.71E+00	9.56E+00	8.83E+02	7.92E+01	9.83E+02	7.18E+02

D&D = deactivation and decommissioning
EMDF = Environmental Management Disposal Facility
ORNL = Oak Ridge National Laboratory
RA = remedial action
Y-12 = Y-12 National Security Complex

Table B.6. Total EMDF waste radionuclide inventory (Ci decayed to 2047)

Waste mass (g)	ORNL D&D	ORNL RA	Y-12 D&D Alpha-4 and Alpha-5	Y-12 D&D Biology	Y-12 D&D Remaining Facilities	Y-12 RA	EMDF Waste Total Inventory (Ci)	EMDF waste average activity concentration (pCi/g)
	1.94E+11	1.81E+11	1.37E+11	2.81E+10	3.03E+11	5.26E+11	1.37E+12	
Radio-isotope	EMDF activity by waste stream (Ci)							
Ac-227	7.54E-03						7.54E-03	5.50E-03
Am-241	4.09E+01	1.11E+02	2.20E-03	5.11E-03	1.80E-02	3.61E-01	1.52E+02	1.11E+02
Am-243	5.30E-01	7.12E+00					7.65E+00	5.59E+00
Ba-133	Refer to Attachment B.3 for basis of inventory estimate						4.14E+00	3.02E+00
Be-10	Refer to Attachment B.3 for basis of inventory estimate						6.52E-05	4.76E-05
C-14	1.66E+00	4.60E+00		1.17E+00			7.43E+00	5.43E+00
Ca-41	Refer to Attachment B.3 for basis of inventory estimate						1.09E-01	7.92E-02
Cf-249	2.80E-06						2.80E-06	2.05E-06
Cf-250	1.91E-05						1.91E-05	1.39E-05
Cf-251	5.42E-07						5.42E-07	3.96E-07
Cf-252	3.37E-07						3.37E-07	2.46E-07
Cm-243	1.01E+00	1.02E-01					1.11E+00	8.10E-01
Cm-244	3.23E+02	2.53E+00	5.39E-04				3.26E+02	2.38E+02
Cm-245	9.87E-02						9.87E-02	7.21E-02
Cm-246	4.10E-01						4.10E-01	2.99E-01
Cm-247	2.68E-02						2.68E-02	1.96E-02
Cm-248	1.44E-03						1.44E-03	1.05E-03
Co-60	4.23E-02	7.90E-03	8.87E-04			4.20E-04	5.15E-02	3.76E-02
Cs-134	5.41E-09	2.19E-08					2.73E-08	1.99E-08
Cs-137	4.11E+02	2.63E+03	2.73E-02	3.71E-03	1.42E-02	2.84E+00	3.04E+03	2.22E+03
Eu-152	7.25E+01	1.46E+00					7.40E+01	5.40E+01
Eu-154	1.65E+01	2.52E-01					1.67E+01	1.22E+01
Eu-155	1.72E-02	1.44E-04					1.74E-02	1.27E-02
Fe-55		2.31E-06					2.31E-06	1.68E-06
H-3	2.52E+01	3.56E+00		6.25E-02			2.88E+01	2.10E+01
I-129	9.56E-01	9.35E-02					1.05E+00	7.66E-01
K-40	1.07E+00	3.43E+00		6.27E-01		3.33E+00	8.46E+00	6.18E+00
Mo-100	1.08E-05						1.08E-05	7.92E-06
Mo-93	Refer to Attachment B.3 for basis of inventory estimate						1.00E+00	7.30E-01

[iv] https://www.tn.gov/content/dam/tn/environment/water/tn-h2o/documents/plan-%26-appendices/wr-tnh2o_plan-report.pdf

[v] A Review of the Performance Assessment and Composite Analysis for the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee, October 12, 2020 (NAC-0131_R1)

[vi] https://www.tn.gov/content/dam/tn/environment/water/tn-h2o/documents/plan-%26-appendices/wr-tnh2o_plan-report.pdf

[vii] *Focused Feasibility Study for Water Management for the Disposal of CERCLA Waste on the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2664&D2)